Observation and Analysis of the Modification of Landfalling Storms By Coastally Trapped Flows

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LONG-TERM GOALS

The goal of this project is to better understand the interaction of synoptic storm features such as fronts, with coastal terrain. The focus is to document the detailed structure and evolution of these features in the coastal zone and compare these results with the output from mesoscale numerical weather prediction (NWP) model forecasts. These comparisons will ultimately provide guidance for improving the sub-grid scale parameterizations in these models.

OBJECTIVES

The objective of our work has been to collect and analyze observations of the evolution of turbulent-scale and mesoscale storm structures in the vicinity of coastal terrain. These observations are forming the basis for comprehensive validations of high-resolution NWP simulation experiments. Our project (summarized in Bond *et al.*, 1997) is intended to complement the research being conducted on warm season coastal phenomena along the U.S. West Coast, which involves a different type of marine boundary layer and large-scale background forcing. This work is supported by ONR Marine Meteorology.

APPROACH

Observational case studies are being carried out based largely on data collected by a NOAA P-3 research aircraft during the Coastal Observation and Simulation with Topography (COAST) field experiments of December 1993 and 1995. We have taken the lead in documenting the characteristics of the low-level turbulence using measurements from the gust-probe/radome system on the P-3. Along with these turbulent structures, mesoscale circulations are being determined from the flight-level and airborne Doppler radar observations. These observations are being compared with specific details from high-resolution NWP simulations, currently with NRL's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS), and in the future, with the Penn State/NCAR Mesoscale Model (MM5). Our focus here is being devoted towards evaluating the turbulence parameterizations in these models.

WORK COMPLETED

The co-PI has concentrated on two cases from the December 1995 field work. The data analysis of the warm front of 12/9/95 is complete. The flight-level and Doppler radar observations were used to specify the mesoscale flow as this front made landfall on Vancouver Island. The turbulence

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accompanying this front was specified in three different regions: the warm sector, frontal zone and topographically trapped flow along Vancouver Island. In collaboration with J.D. Doyle of NRL, these results were compared with output from simulation experiments using COAMPS. A two-part manuscript on this case is in preparation. Analysis is continuing on two different aspects of the intense storm of 12/12/95. The detailed nature of the mesoscale and turbulent structures in the very strong (~50 m/s) low-level flow accompanying this storm have been analyzed in collaboration with B.A. Walter of Northwest Research Associates. We anticipate some very important and interesting comparisons with the turbulence parameterizations used by COAMPS and MM5. The co-PI is also collaborating with other investigators involved with the Coastal Meteorology ARI on the landfalling aspects of this storm, as deduced from Doppler radar observations and NWP simulations.

RESULTS

a) The combined observational/modeling case study of the warm front of 12/9/95 provided the opportunity to improve our understanding of the interactions of a variety of processes in a coastal zone proximal to significant topography. The control run from COAMPS produces mesoscale structures and turbulence intensities that are quite similar to those observed. This provides justification for using the internally consistent model output in sensitivity experiments. Both the observations and model output suggest that the front was strengthened and its landfall was slowed by the cool, low-level flow trapped along the windward flank of Vancouver Island. A surprising result concerns the nature of this trapped flow. As shown explicitly in the model experiments, and suggested by the aircraft data, this trapped flow was more due to the topographical gap represented by the Strait of Juan de Fuca rather than the topographical barrier of Vancouver Island. The nature of the outflow from the Strait of Juan de Fuca was sensitive to surface boundary conditions, notably the snow cover, well inland. This case therefore provides an example of a coastal flow remarkably sensitive to remote effects.

b) For the storm of 12/12/95, we have described the vertical profiles of the mean and turbulent properties of the PBL and capping stable layer in a region of low-level flow approaching 50 m/s. Our results show that the greatest turbulence was occurring within the PBL in the vicinity of the strongest low-level flow. Substantial turbulence was occurring not just where the Richardson number was small below the core of the jet, but also to the sides of the jet, presumably due to horizontal shear instabilities. The near-Lagrangian measurements of this flow made by the aircraft will be used to estimate the terms in a momentum budget. The preliminary results from analysis of the Doppler radar data during the landfall of the low suggest that the pressure gradients and the winds near the low center were slackening. NWP model experiments now being undertaken should help elucidate the extent to which the evolution of the low can be attributed to the effects of the coastal terrain.

IMPACT/APPLICATIONS

The COAST experiment collected a unique set of detailed observations of landfalling storms to compare with high-resolution NWP simulations. In particular, we coordinated the collection of unprecedented flight-level and airborne Doppler radar measurements in a coastal environment proximal to prominent terrain. These measurements have been used, and are still being used, by us and other researchers associated with the Coastal Meteorology ARI to address some of the outstanding issues regarding the upstream effects of terrain on storms.

REFERENCES

Bond, N.A., C.F. Mass, B.F. Smull, R.A. Houze, M.-J. Yang, B.A. Colle, S.A. Braun, M.A. Shapiro, B.R. Colman, P.J. Neiman, J.E. Overland, W.D. Neff, J.D. Doyle, 1997: The Coastal Observation and Simulation with Topography (COAST) Experiment. *Bull. Amer. Meteor. Soc., 78*, 1941–1955.

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Doyle, J.D., and N.A. Bond, 1998: A landfalling warm front on Vancouver Island during the COAST Experiment: Numerical simulations. 2nd Conference on Coastal Atmospheric and Oceanic Prediction and Processes, *Amer. Meteor. Soc.*, Phoenix, AZ, 11–16 January 1998, 212–214.

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